TO: Chairman Brian Baird, Chairman Subcommittee on Energy and Environment, House Committee on Science and Technology, U.S. House of Representatives

FROM: Drs. Kristiina and Daniel Vogt

SUBJECT: Testimony on 'Mobile Methanol Technology: its Potential for Energy Security, Jobs and Mitigating Climate Change'

DATE: April 20, 2009

This testimony will summarize four topics:

- TOPIC 1: Brief overview of mobile bio-methanol technology, the scale of the technology, and multiple methanol markets
- TOPIC 2: Public and private sector collaborations to develop this technology
- TOPIC 3: Future research needs to overcome barriers to adopting this technology
- TOPIC 4: Costs and benefits of bio-methanol technology for rural communities and its economic benefits and environmental services

## Setting the Stage

Rural communities have been interested in developing local industries to create jobs and revitalize their economies. Mostly, the options recently pursued have been the creation of jobs from computer software related, or tourism related, industries and away from the forest industry focus that used to be the main industry providing higher paying employment opportunities in the past. However, the long-term sustainability of such activities has not proven as reliable as the traditional economic uses of forests. Utilizing unused or underutilized forest materials, woody biomass, in the production of energy, bio-fuels, and/or bio-fuel components allows for a "triple win." Such utilization can create new sustainable jobs in traditional industrial sectors; develop new sources of "green," sustainable and renewable fuel and energy sources to meet growing national demands; and, provide a market incentive to costly management activities that can create increased habitat for wildlife.

Our project is a Washington collaborative initiative forged between two towns, two American Indian First Nations, faculty and graduate students from the College of Forest Resources and Business School at the University of Washington, a for-profit-company [Renewol LLC] that has initiated the development of the mobile technology, and the Washington State Labor Union. The core of this collaborative initiative is to utilize woody biomass, currently not utilized in lumber/paper production, and convert this biomass using decentralized processors to develop liquid fuels while producing new jobs and new markets in rural areas. Part of this initiative is to develop the manufacturing infrastructure and professional forestry and business capacity to provide sustainable energy solutions from forests while mitigating carbon emissions in Washington. The goals of this collaborative initiative are: produce bio-methanol and become the suppliers to multiple traditional industries (e.g., transportation fuels) and to the newly emerging small appliances industries

(e.g., replacing batteries with methanol-fuel cells); build the infrastructure in both the east side and west sides of Washington to manufacture mobile biomass-to-methanol facilities to sell in Washington, other regions of the US and other targeted regions of the world; new job creation in forestry and business; partnering with other Washington industries to provide component parts to build the technology; and to identify the marketing distribution channels and form supply contracts with businesses using our product (e.g., small appliances powered by methanol-fuel cells).

Forest materials are highly amenable to distributed production but no pilot project has demonstrated this potential. There are no technological barriers or new technologies needed to integrate the technology for building mobile biomass conversion facilities. Utilizing and adapting existing technologies to process various forest materials creates greater marketable opportunities associated with the adoption of mobile technology.

Conversion of woody (ligno-cellulosic) biomass to alcohol (methanol) is not a new process – a common name for methanol is wood alcohol, since in the 19th century and earlier, wood was the source. However with the advent of plentiful and cheap fossil fuels in the 20th century, wood conversion was no longer competitive economically, and the process fell out of use. China, however, has decided to pursue methanol as its alcohol of choice but is using new technology to convert coal into methanol. In 2007, China became the world's largest methanol producer and consumer (Energy: China leads world in methanol fuel blending 31 Jan 2008; http://www.bbj.hu/main/news_35709_energy:+china+leads+world+in+methanol+fuel+blending.html). China leads the use of methanol as alternative transportation fuel, blending nearly one billion gallons of methanol in gasoline. Taxi and bus fleets running on high methanol blends (M-85 to M-100), and retail pumps sell low level blends (M-15 or less) in many parts of the country.

# TOPIC 1: Overview of bio-methanol technology, the scale of the technology, markets for bio-methanol

## 1. Technology

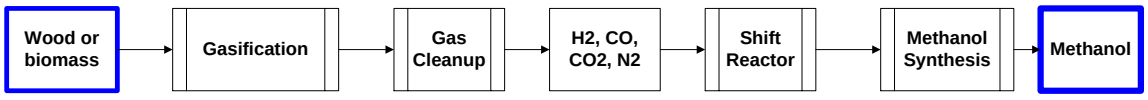
Our partner, Renewol LLC, will coordinate the scaling of existing state of the art technologies to the sizes and throughputs required by a small scale mobile facility and which is compatible with the type and amounts of available wood fiber or wastes. This will require the scaling and integration of the following four existing technology components:

1. Biomass gasifier
2. Cleanup of the raw syngas to remove particulates and tars
3. Balancing of the syngas to get approximately 2:1 $H_2$ to CO ratio
4. Catalytic conversion of the balanced syngas to methanol

Small scale biomass gasification is a developed technology; it remains to be demonstrated that this technology can be integrated to produce a liquid fuel, e.g. methanol, efficiently while mounted on a truck trailer. The gasifier must be developed to the required standards of reliability, maintainability, and availability needed by an integrated system. Among the issues to be addressed are: integration of the above listed four components so that all the parts function at the same rate, the rate of feeding different biomass materials into the gasifier, how to remove ash continuously, material compatibility, and process control.

Shift reaction and methanol synthesis are well-developed and commercially available on large scale. The existing technology must be scaled to suit the mobilization of the Renewol application.

A simplified process flow diagram is shown below:




## 2. Scale of the technology

Forest materials are highly amenable to distributed production using mobile technology because forest biomasses are distributed across large landscapes and there is a need to transport this biomass to centralized facilities; this is also prohibitively costly. Maintaining centralized facilities designed to convert biomass wastes to energy is challenging today because the biomass quantity has to be sufficiently great to make these facilities economic to operate. Transportation costs, however, limit economically viable biomass collection to an approximate 60 to 100 miles haul distance from the facility. Thus, large centralized facilities (e.g., cogeneration, ethanol production) are being closed down because of insufficient biomass supplies.

Regional, distributed production of biofuels using mobile or small stationary systems has advantages over larger centralized plants. For example, feedstock transportation cost will be lower, and the residual waste disposal problem (ash - contains all the minerals originally part of the tree biomass except for the volatile nutrients like nitrogen) is mitigated by putting the ash back on the site from which the biomass came. Removal of woody biomass to centralized facilities can reduce the nutrient status of the forests where these materials were collected. However, if mobile conversion systems are used to produce methanol at the collection site, the ash remaining after the conversion process becomes fertilizer that can be applied at the site where the material was collected.

The development and deployment of transportable processors of woody-biomass can also prevent the problems that arise when an existing centrally located mill is no longer able to operate and contribute to broader national and global market forces. Similar problemss are now being experienced in the emerging biofuels industries with the closing of several large scale biomass-to-alcohol plants recently, or on the brink of closure, due to market conditions or conditions associated with insufficient supplies of biomass to feed the facility. Utilizing decentralized, mobile processors provide a preliminary, or market ready, material ensures the ability of rural communities to utilize woody-biomass in a manner that does not require dependence upon "one user/purchaser."

## 3. Markets facts for Methanol Production

One of the benefits of methanol is that it can be used by many different industries so that rural communities would have the ability to supply a diversity of markets and are less influenced or vulnerable to changing global market demand. Examples of methanol markets are:

- **Transportation fuels**: bio-methanol can replace petroleum as a transportation fuel. It is already sold as M85 (85% methanol, 15% gasoline or diesel). Methanol is also used to transform vegetable oils to biodiesel, where 10% of biodiesel is methanol. Today, manufacturing facilities with annual capacities of 10 to 60 million gallons of biodiesel are being built. These facilities each require 1 to 6 million gallons of methanol annually to produce the biodiesel. According to the Methanol Institute: "The Energy Policy Act of 2005 established a Renewable Fuel Standard requiring that a growing share of the nation's transportation fuel pool is met with fuels like biodiesel. In addition, federal requirements to lower sulfur levels in conventional diesel will encourage the use of biodiesel (added to the petrodiesel) to act as a lubricant to keep engines running smoothly."

- **Electricity:** Methanol can be used in gas turbines to generate electricity, in fact, is considered a superior fuel for this use. In the future methanol will be used to power hydrogen fuel cells to produce electricity yielding higher efficiencies of conversion compared to turbines and allowing smaller scale generation. For example, a typical 3 bedroom (~2,000ft$^2$) house in Seattle (needing 833 kWh per month) that derives its electricity from methanol fuel cells could obtain 2 months of electricity from the

methanol extracted from 3 tons of wood (assumption: 16 hours continuous power generation, 0.5 gallons methanol consumed by fuel cell/hr, 166 gallons methanol/1 dry T biomass).

- **Battery Replacement**: Small appliances and personal electronics devices of the near future will be powered by methanol fuel cells as well as by batteries. Computers and MP3 players already exist that run for 20 hours on a single refueling of a methanol-fuel cell. Nearly every major electronics manufacturer plans to release portable electronics powered by methanol fuel cells within the next year.

- **Waste Treatment**: Methanol is used by hundreds of wastewater treatment plants to control nitrate pollution - a growing problem as areas experience population growth. Large waste treatment plants using methanol denitrification cost $100 million less than the closest alternative for nitrate removal.

## TOPIC 2: Public, Private Collaborations

The development of the technology discussed in TOPIC 1 has flourished because of the diversity of collaborators (e.g., chemical engineers, city attorney, public utility manager, ecosystem ecologists, foresters, natural resource managers from the tribes and Washington state, business people, economists, marketers, tribal cultural managers). All collaborators are interested in using locally available materials and integrating new technologies to create a diversity of rural development opportunities. This group is also interested in building the capacity of these communities so they can manage this technology in an environmentally and socially acceptable manner. It has been difficult to re-introduce economic opportunities into rural areas that pay salaries higher than subsistence levels. Our solution is to use local resources to provide environmentally friendly energy that can be used to decrease the vulnerability of rural and indigenous communities to global markets. The role of our collaborators can be summarized as:

- On the technology side, this was a collaborative effort between:
  - Scientists from Renewol LLC coordinated and identified the technical partnerships required to design the mobile bio-energy technology, assessed how to make the technology appropriate for different forest types and societal expectations/acceptability of the technology, and acquired the original funds to conduct a patent search for the technology, and to introduce the concept to forest stakeholder communities
  - Scientists from Lawrence Livermore National Laboratory determined the feasibility of the idea and the design; and conducted preliminary economic analyses of the mobile technology. The library patent search was conducted by LLNL.
  - Scientists in a company that builds fuel cells powered by methanol (IdaTech LLC, Bend, OR) advised Renewol about the development of the technology and the quality of methanol that needed to be produced for fuel cells.

- Several groups collaborated on identifying the constraints and opportunities for adopting the technology and capacity building in rural and indigenous communities. There are several elements to these collaborations: 1) Developing assessment tools to evaluate the sustainability of adopting this technology in rural areas of Washington, Alaska, Oregon, Montana, Indonesia, India, Namibia, Costa Rica, Haiti; 2) Designing a harvesting approach that would be economically, socially, culturally and environmentally acceptable in rural areas and on Native American lands; 3) Developing business plans for the marketing and distribution of products produced using this technology.
  - Scientists and graduate students from the College of Forest Resources and from the Business School
  - Town of Forks, WA and Republic, WA
  - The Confederated Tribes of the Colville, Yakama Nation

- Recent collaborations are helping to strategize on the building of the manufacturing facilities in Washington and in identifying relevant manufacturing partners to manufacture the technology at some locations in Washington.
  - Jim Tusler, Bob Guenther, Bill Messenger representing the Washington State Labor Council

The City of Forks made the development of 'Washington Rural Wood-Biofuels Collaborative' as their FY2010 Appropriations General Request. This collaborative is a partnership with Renewol LLC; University of Washington College of Forest Resources' Forest Systems and Bio-Energy Program; Ferry County Public Utilities District, and the Confederated Tribes of the Colville. The City of Forks had made a similar request three years ago to the federal government.

## TOPIC 3: Future research on barriers to the adoption of the technology

Most of the barriers to the adoption of our technology are not barriers because of the technology itself. The barriers have arisen because of the competition for controlling what biofuel supplies will be acceptable in the markets and a lack of public understanding of different technologies that can be used to produce biofuels. Components of the mobile integrated systems are commercially available. Preliminary design and assessment of how to integrate these components onto a truck mounted system has occurred. Design and Production Design of the processing system is required. This would be followed by the manufacturing of a pilot processor to be field tested in various locations in the State.

The major barriers to adopting this technology can be summarized as:

- Too many technologies are rapidly being introduced into the markets.
  The engineering technology is rapidly evolving and creates confusion among the public on what technology would be most appropriate to adopt in any given location. This makes the public cautious in accepting new technologies.
- Most attention and funding have been placed toward the production of ethanol from crops (and now from cellulosic materials) and ethanol producers have not accepted methanol production derived from wood.
  This situation has resulted in a lack of market recognition of raw material supply since no mobile methanol generator of the kind designed by Renewol is now on the market.
- Major competitors (e.g., cellulosic ethanol producers, traditional users of waste and low quality wood; natural gas and coal based methanol producers) are worried that they will lose raw material supply capacity or the markets for their products if another liquid fuel was introduced into the markets.
  The major competitors/players do not want to see a new product on the market because they perceive that this technology will diminish their market niche and supply sources, they are worried about diminished public acceptance of centralized systems of energy production and the use of fossil fuels to produce this energy if the consumption of renewable energy increases.

**Future Potential Barriers:**

We have considerable information on the availability of biomass supplies across large landscapes but limited information on the criteria needed to make decisions concerning when, where and how to collect biomass sustainably from multiple forestland owners while satisfying the regulatory and social/cultural requirements of all the stakeholders. There is a need to ensure that methanol production is environmental and can be certified as sustainably produced by a credible certification organization. Existing certification protocols are not designed to assess or incorporate biofuels production into their assessments. There is also a need to incorporate tribal values into a certification approach for it to be accepted by tribal members. If assessment protocols are not designed to assess these other uses of forests and to include rural and tribal values, this could become a barrier even if the process complies with applicable "green certifications."

There is a need to identify the local, regional, and international industries and consumer markets for liquid fuels (e.g., biodiesel companies, gas stations, small appliances powered by methanol-fuel cells such as computers, cell phones, heavy equipment) so that once methanol is produced, the distribution channels are active and viable. If these data do not exist, it will become a barrier to the use of this technology since it will not be economically viable. Business and market information on methanol distribution and consumer markets are available nationally and internationally but not for Washington state. Research will need to be conducted to identify and develop market contacts associated with products that use methanol and similar biofuel components. Providing processed materials for assessment and potential testing/use would be required.

## TOPIC 4: Costs and benefits to rural and indigenous communities, Washington economies and environmental services

To obtain the multiple benefits possible from using wood, new technologies need to be introduced that are capable of diversifying the economic markets in rural areas. If the economic markets are not diversified, it will be difficult to revitalize rural economies since they will have no buffering if the demand for the 'one' product dissipates. Recently, there has been a movement towards diversifying the product stream from pulp mills by converting these mills into bio-refineries (with paper becoming a side product). This diversification is a good trend adding new market options for mills but it may only revitalize rural communities at some locations and probably not across larger rural landscapes. However, many mills have closed in rural communities during the last couple of decades making it is less likely that they will be rebuilt because each costs millions of dollars to rebuild.

Wood materials are not being used to their full potential. Today, the chief energy use of wood fiber and waste is production of electricity via combustion and steam turbines (i.e., cogeneration). Although this sector is growing, it is limited by air pollution regulations on what it can emit. The Renewol process can process a much wider variety of wood fibers including those impregnated with chemicals. Also the Renewol process can successfully compete with cogen since it creates methanol, a higher valued product. Wood fibers are also being gasified to feed an internal combustion engine to generate electricity (e.g., BioMax 15). These systems do not produce a transportation fuel, but generate electricity at a given location. The value of methanol produced from a unit of wood waste could be much greater than the value of electricity that can be produced from that wood.

It has been very difficult to acquire funds to develop alternative energy production systems that are small scale because these systems do not generally appear to provide "as significant an economic return." Today, the need to achieve or alleviate environmental or climatic impacts of energy use has made alternative energy production systems viable at smaller scales. Industries are being taxed for the carbon that they emit and are now willing to pay for more environmentally friendly energy to mitigate their emissions. Industries also face shortages of, or higher prices for, the energy they need to power their industrial processes. Fortunately, some of the alcohols produced from forest materials have multiple market outlets and can be produced at a cost that makes them competitive with alcohols produced from fossil fuels. Because of the efficiency of the conversion of forest material to alcohols (50%), a smaller amount of biomass will produce a sufficient enough quantity of alcohols to decrease the cost of the biomass-derived alcohol and make it cost competitive.

### 1. Environmental benefits

Forests in Washington are highly altered because of past land-use practices and are currently strained to provide the multiple outcomes (forest products, enhanced wildlife habitat, recreational uses, etc.) at the level society expects. In Washington, it should be unacceptable and is unsustainable to not consider managing forests to increase their health, environmental

benefits, economic uses, and reduce risks of catastrophic fire or blowdown. Sufficient funds to restore these forests to sustainable conditions do not exist. Lacking market incentives to utilize forested biomass from pre-commercial thinning operations, the costs to transition young forests into either enhanced habitat or commodity production will continue to outstrip the available funds of land managers. There are few markets or products that can be produced from low quality wood fiber or landfill-bound wood waste so these materials are mainly left at logging landing sites, piled-burned or disposed of in landfills. None of these practices are environmental and incur costs with no benefits to forest landowners. Washington needs to manage forest health and to reduce their fire risk but few markets/products can be produced from low quality wood fiber or landfill bound wood waste.

Methanol produced from biomass is a ready substitute for natural gas methanol. Virtually all the methanol produced in the U.S., and most of the methanol produced globally, is from natural gas. Natural gas supplies are in high demand for other uses and prices are rising. So producing bio-methanol from woody materials can begin to provide regional energy security by substituting for processes currently utilizing natural gas derived methanol.

Methanol is environmentally beneficial because it can help to reduce carbon emissions from fossil fuels. The California Energy Commission has reported that M85 would reduce the emissions of toxic air pollutants by 50% compared with gasoline along. "On the positive side, the costs to adapt current infrastructure to accommodate methanol would be similar to those for ethanol and far less onerous than developing an infrastructure to compress and transport hydrogen or liquefied natural gas. Methanol burns cleanly, producing CO2 but eliminating other products of gasoline combustion such as benzene and particulate emissions. Methanol is harder to ignite than gasoline and burns cooler, making it less of a fire hazard. It's also miscible in water, and would likely dilute and biodegrade in a spill." (Kemsley 2007).

Environmental benefits directly as a result of using this technology:

- Less fossil $CO_2$ is emitted overall in Washington when substituting a carbon neutral renewable liquid fuel for fossil fuels.
- Reducing the fire risk of Washington forests will also minimize $CO_2$ emissions when trees burn during catastrophic fires.
- Improve forest health and reduce fire risk problems by being able to economically manage forests because of the revenues provided by the conversion of small diameter forest materials to liquid fuels.
- Increase the use of renewable energy as part of the energy mix of Washington state and increase efficiency of energy usage because mobile systems eliminate the transportation limits imposed by centralized energy production systems.

**2. Markets and Rural Revitalization**

Bio-methanol can be a 'niche market' for rural and Native American communities. Currently, there are no known producers of "Green methanol". Natural gas supplies, another source, are

uncertain and prices are rising, and the economic production of methanol from coal is in its infancy. The chief competition for "Green methanol" as a transportation fuel will be other green fuels - biodiesel or E85 (85% ethanol produced from agricultural crops, plus 15% gasoline). There are no forecasts of market saturation by either of these sources in the foreseeable future. Regulations that encourage use of these biofuels should also include support of bio-methanol use. The market size for methanol in the U.S. is currently over $4 billion dollars; the growing demand for alternative transportation fuels in the United States will cause the methanol market to grow proportionally. The demand for methanol is increasing at a healthy 4 percent per year globally, according to the Methanol Institute.

The conversion of the currently unused/under-utilized woody-biomass into new products would result in the developing of new jobs and markets in rural Washington. Most tribal and other rural communities face few job options and high unemployment rates. Most industries are not going to relocate to rural areas so there is a need to develop industries that can be local or regional and are based on using local materials to produce a product that has a diversity of market demand at local/regional, national and international levels and has export potential.

Developing new jobs and new markets in rural areas, or on tribal lands, has been pursued on many levels. However, most successful programs arise when local resources are utilized that are readily available and sustainable. When involving natural resources, new job creation efforts have to address rural economic needs and expectations, while at the same time addressing more urban-centered environmental compliance demands. Utilizing woody biomass as a new market for bio-fuels, and bio-fuel components within existing forest practices, could align various expectations and create new opportunities for industry, environment, and local economies.

The benefit of such a dual approach is that solutions are being pursued for increasing rural economic viability and sustainability by using forest materials to develop new products and energy at the same time. Tribes and rural communities could become methanol suppliers to the newly emerging markets in small appliances powered by methanol-fuel cells, or as a provider of methanol for use as motor vehicle bio-fuels. Forest waste biomass has the added benefit of not competing with food crops, existing lumber products, and can be collected in such a way that no land-use alterations are needed. The benefits of adopting mobile units to convert forest materials to liquid fuel can be summarized as:

## 3 Jobs

**DIRECT EMPLOYMENT OPPORTUNITIES**

Direct impacts of this project are: development of ~50 new jobs per mobile integrated system ranging from those employed in the collection of the biomass, foresters developing management plans that can be certified to be sustainable so carbon credits can be obtained and the collection can be certified to be sustainable, those associated in the transportation of the liquid fuels, and those with engineering education who need to maintain and repair the integrated systems. Since

the goal is to have a minimum of 20 mobile systems in operation at any time, producing the liquid fuels project will ultimately produce:

- ✓ **~1,000 NEW JOBS**

Many other jobs will result from implementing these mobile renewable energy systems: building a manufacturing facility in a rural area to construct and sell these units, individuals to market and distribute the liquid fuels to markets. Each manufacturing facility will create **~50 NEW JOBS** while the marketing and sales will create **~ 10 NEW JOBS.**

**Estimated Employment Created for One Mobile Methanol System in Operation (does not include foresters developing management plan, certification, transport of liquid fuels, educators or trainers)**

| Function | Job Duties | # of Direct Employment | Area of Employment | Indirect Employment | Other Rural Development |
|---|---|---|---|---|---|
| Plan Harvest | Determine areas for harvest | 2, depends on scope | Tribe, DNR, Forest Service, County | Support personal | Develop forest management technology, (GIS, remote sensing) through local community college |
| Acquire Raw Materials | Collect material | 3 | Rural area | | |
| Process Material | Drive truck, operate system, load material | 3 | Rural area | Repair/ Maintain equipment | |
| Distribute Methanol | Transport methanol to wholesale, retail markets | 2 | Rural Area | Distribution Facilities | Component of Biodiesel<br>Fuel for Fuel Cell |
| **TOTAL** | | **10** | | | |

**Estimated Employment Created Constructing Mobile Methanol System (Beginning numbers, increases expected over time)**

| Function | Job Duties | # of Direct Employment | Area of Employment | Indirect Employment | Other Rural Development |
|---|---|---|---|---|---|
| Construct System | Build, design system | 30-50 | Rural area, Reservation | Parts suppliers, Facilities for production | Develop Technical Training at local community college to support system |
| Marketing and Sales | Develop regional, national, international markets | 10 | Rural area, Reservation | | |
| **TOTAL** | | **40-60** | | | |

Since biofuels production takes local materials found in rural areas, it is ideal for rural revitalization and does not compete with existing rural jobs. It has the potential to re-establish the economic viability of rural areas and reduce the vulnerability of rural areas to global market drivers. Timber used to be a viable industry in rural areas of Washington but has been dramatically reduced due to conservation concerns, the losses of old growth forests as well as the fluctuations in global timber prices and the shift in which regions of the world are the preferred global suppliers of timber. There is urgency to provide alternative options for rural and tribal revitalization that can be locally based.

Based on EU studies, the replacement of fossil fuels by even a small portion of biofuels appears to trigger the development of thousands of new jobs. According to a European Union study, for every 1% that biofuels replaces total fossil fuels consumed, 45,000 to 75,000 new jobs will be created in rural areas (http://www.agrinergy.ecologic.eu/download/background_note_workgroup1_lei.pdf). It has also been suggested that more jobs will be created from producing renewable energy than continuing to use fossil fuels to produce energy. Kammen et al. (2004) has also reported that you get three to five times the amount of jobs in the renewables area than you do in fossil fuels (http://rael.berkeley.edu/old-site/renewables.jobs.2006.pdf).

## INDIRECT EMPLOYMENT OPPORTUNITIES

The indirect impacts of this project are: Decreasing unemployment occurring in Washington organizations and companies by developing new demands for either the expertise they provide (DNR employees involved in designing tree harvesting strategies that are certifiable as being sustainable, developing policy relevant for biofuels to become a product provided by organizations such as the DNR to meet its fiduciary responsibilities to its trusts) or for the products that they produce (e.g. trucking companies, gas stations, biofuel producers, fuel cell companies, small appliance businesses). In the EU, it has been estimated that every job in biomass conversion to renewable energy will result in at least 10 additional jobs. If this amplifier effect is correct, the potential of adopting 20 of these integrated units and 1 operational manufacturing facility can result in **~2,600 JOBS WITH MORE SECURITY.** A study conducted in Oregon in 2006 suggests that each direct job will result in 2-3 indirect jobs which would result in **520 to 780 SECURE JOBS** (http://www.oregonforests.org/media/pdf/Biomass_highlights.pdf).

Training will be needed for tribes and other rural people to be employed in the new industries and new markets that will result from adopting these integrated systems. This will open up opportunities for educational institutions such as Community Colleges (and/or technological schools/centers) to integrate new curricula into their activities.

The benefits of adopting mobile bio-energy technology are many fold and can be summarized as:

- Increase rural economic viability and sustainability by using biomass to develop new products and energy
- Contribute to regional climate change mitigation by promoting the use of environmentally sound approaches to renewable resource (forest materials) utilization
- Promote the ecosecurity of forests by managing forest materials, which currently have little economic value, to reduce the risk of fire
- Deployment of potentially 20 mobile systems in Washington and franchising these units
- Training program as part of core Community College and/or technological schools/centers curricula.

- Industries in Washington state selling manufactured mobile systems to other regions in the US and international markets in Asia, Africa, Europe, Central and South America
- Contributing towards the revitalization of other Washington industries, e.g., providing bio-methanol to biodiesel producers at prices lower than the current wholesale costs so that biodiesel costs per gallon can decrease
- Providing and supporting direct and indirect employment of >10,000 people in Washington from adopting 1 mobile unit and the building of 1 manufacturing facility
- New markets developed in rural areas and partnerships created with different landowners (tribes, NIPF, Forest Service, DNR) to co-manage the supply capacity of forest materials
- A significant amount of fossil fuel would be replaced by bio-methanol by the process described here since each bone-dry ton of woody biomass is converted to 150-186 gallons of methanol depending on the biomass type. Each pilot plant can process from 5-10 bone-dry tons of woody biomass per day and it is ultimately expected that there would be a minimum of 20 units in operation between years 2-5. Washington could sustain more than 100 mobile units during the process of improving forest health in rural as well as in urban areas.
- Allow tribes and rural communities to formally be part of opportunities being created by federal programs such as the West-wide Energy Corridor PEIS by contributing locally produced liquid fuels from biomass to the proposed energy corridors